ARMY STTR 16.A
PROPOSAL SUBMISSION INSTRUCTIONS

The approved FY16.A topics solicited for the Army Small Business Technology Transfer (STTR) Program are listed below. Offerors responding to this Solicitation must follow all general instructions provided in the Department of Defense (DoD) Program Solicitation. Specific Army STTR requirements that add to or deviate from the DoD Program Solicitation instructions are provided below with references to the appropriate section of the DoD Solicitation.

The STTR Program Management Office (PMO), located at the United States Army Research Office (ARO), manages the Army's STTR Program. The Army STTR Program aims to stimulate a partnership of ideas and technologies between innovative small business concerns (SBCs) and research institutions (RIs) through Federally-funded research or research and development (R/R&D). To address Army needs, the PMO relies on the collective knowledge and experience of scientists and engineers across nine Army organizations to put forward R/R&D topics that are consistent with their mission, organization, and STTR program goals. More information about the Army STTR Program can be found at https://www.armysbir.army.mil/sttr/Default.aspx.

For technical questions about specific topics during the Pre-Solicitation period (11 Dec 2015 – 10 Jan 2016), contact the Topic Authors listed as POCs for each topic in the Solicitation. To obtain answers to technical questions during the formal Solicitation period, visit https://sbir.defensebusiness.org/sitis. For general inquiries or problems with the electronic submission process, contact the DoD Help Desk at 1-800-348-0708 (9:00 am to 6:00 pm ET). Specific questions pertaining to the Army STTR Program should be submitted to:

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PHASE I PROPOSAL GUIDELINES

Phase I proposals should address the feasibility of a solution to the topic. The Army anticipates funding two STTR Phase I contracts to small businesses with their research institution partner for each topic. The Army reserves the right to not fund a topic if the proposals received have insufficient merit. Phase I contracts are limited to a maximum of $150,000 over a period not to exceed six months. Army STTR uses only government employees in a two-tiered review process. Awards will be made on the basis of technical evaluations using the criteria described in this DoD solicitation (see section 6.0) and availability of Army STTR funds.

The DoD SBIR/STTR Proposal Submission system (https://sbir.defensebusiness.org/) provides instruction and a tutorial for preparation and submission of your proposal. Refer to section 5.0 at the front of this solicitation for detailed instructions on Phase I proposal format. You must include a Company Commercialization Report (CCR) as part of each proposal you submit. If you have not updated your commercialization information in the past year, or need to review a copy of your report, visit the DoD SBIR/STTR Proposal Submission site. Please note that improper handling of the CCR may have a direct impact on the review and evaluation of the proposal (refer to section 5.4.e of the DoD Solicitation).

Proposals addressing the topics will be accepted for consideration if received no later **6:00 a.m. Eastern Time, Wednesday, 17 February 2016**. The Army requires your entire proposal to be submitted electronically through the DoD-wide SBIR/STTR Proposal Submission Web site (https://sbir.defensebusiness.org/). A hardcopy is NOT required and will not be accepted. Hand or electronic signature on the proposal is also NOT required. STTR Proposals consist of four volumes: Proposal Cover Sheet, Technical Volume, Cost Volume and Company Commercialization Report. Army has established a **20-page limitation** for Technical Volumes submitted in response to its topics. This does not include the Proposal Cover Sheets (pages 1 and 2, added electronically by the DoD submission site), the Cost Volume, or the CCR. The Technical Volume includes, but is not limited to: table of contents, pages left blank, references and letters of support, appendices, key personnel biographical information, and all attachments. The Army requires that small businesses complete the Cost Volume form on the DoD Submission site versus submitting it within the body of the uploaded Technical Volume. Proposals must be submitted in Portable Document Format (PDF), and it is the responsibility of submitters to ensure any PDF conversion is accurate and the Technical Volume portion of the proposal does not exceed the 20-page limit. Any pages submitted beyond the 20-page limit will not be read or evaluated. If you experience problems uploading a proposal, call the DoD SBIR/STTR Help Desk 1-800-348-0708 (9:00 am to 6:00 pm ET).

Companies should plan carefully for research involving animal or human subjects, biological agents, etc (see sections 4.7 - 4.9). The short duration of a Phase I effort may preclude plans including these elements unless coordinated before a contract is awarded.

If the offeror proposes to employ a foreign national, refer to sections 3.5 and 5.4.c (7) in the DoD Solicitation for definitions and reporting requirements. Please ensure no Privacy Act information is included in this submittal.

If a small business concern is selected for an STTR award they must negotiate a written agreement between the small business and their selected research institution that allocates intellectual property rights and rights to carry out follow-on research, development, or commercialization (section 10).

PHASE II PROPOSAL GUIDELINES

Commencing with the STTR FY13.A cycle, all Phase I awardees may apply for a Phase II award for their topic – i.e., no invitation required. Please note that Phase II selections are based, in large part, on the success of the Phase I effort, so it is vital for SBCs to discuss the Phase I project results with their Army Technical Point of Contact (TPOC). Army STTR does not currently offer a Direct to Phase II option. Each year the Army STTR Program Office will post Phase II submission dates on the Army SBIR/STTR web page at https://www.armysbir.army.mil/. The submission period in FY16 will be 30 calendar days starting on or about 10 February 2017. The SBC may submit a Phase II proposal for up to three years after the Phase I selection date, but not more than twice. The Army STTR Program *cannot* accept proposals outside the Phase II submission dates. Proposals received by the Department of Defense at any time other than the prescribed submission period will not be evaluated.

Phase II proposals will be evaluated for overall merit based upon the criteria in section 8.0 of this solicitation. STTR Phase II proposals have four Volumes: Proposal Cover Sheet, Technical Volume, Cost Volume and Company Commercialization Report. The Technical Volume has a **38-page** limit including: table of contents, pages intentionally left blank, technical references, letters of support, appendices, technical portions of subcontract documents (e.g., statements of work and resumes) and any attachments. However, offerors are instructed to NOT leave blank pages, duplicate the electronically generated cover pages or put information normally associated with the Technical Volume in others sections of the proposal submission as these will count toward the 38-page limit. ONLY the electronically generated Cover Sheets, Cost Volume and CCR are **excluded** from the 38-page limit. As instructed in section 5.4.e of the DoD Program Solicitation, the CCR is generated by the submission website based on information provided by you through the "Company Commercialization Report" tool. **Army Phase II proposals submitted containing a Technical Volume over 38 pages will be deemed NON-COMPLIANT and will not be evaluated.**

Small businesses submitting a proposal are also required to develop and submit a technology transition and commercialization plan describing feasible approaches for transitioning and/or commercializing the developed technology in their Phase II proposal.

Army Phase II Cost Volumes must contain a budget for the entire 24 month period not to exceed the maximum dollar amount of $1,000,000. During contract negotiation, the contracting officer may require a Cost Volume for a base year and an option year. These costs must be submitted using the Cost Volume format (accessible electronically on the DoD submission site), and may be presented side-by-side on a single Cost Volume Sheet. The total proposed amount should be indicated on the Proposal Cover Sheet as the Proposed Cost. Phase II projects will be evaluated after the base year prior to extending funding for the option year. Phase II proposals should be structured as follows: the first 10-12 months (base effort) should be approximately $500,000; the second 10-12 months of funding should also be approximately $500,000. The entire Phase II effort should not exceed $1,000,000. The Phase II contract structure is at the discretion of the Army's Contracting Officer, and the PMO reserves the option to reduce an annual budget request > $500,000 if program funds are limited.

DISCRETIONARY TECHNICAL ASSISTANCE (DTA)

In accordance with section 9(q) of the Small Business Act (15 U.S.C. 638(q)), the Army will provide technical assistance services to small businesses engaged in STTR projects through a network of scientists and engineers engaged in a wide range of technologies. The objective of this effort is to increase Army STTR technology transition and commercialization success. The Army has stationed nine Technical Assistance Advocates (TAAs) across the Army to provide technical assistance to small businesses that have Phase I/II projects with the participating Army organizations. Details related to DTA are described in section 4.22 of the DoD Solicitation. For more information go to: https://www.armysbir.army.mil/sbir/TechnicalAssistance.aspx

PUBLIC RELEASE OF AWARD INFORMATION

If your proposal is selected for award, the technical abstract and discussion of anticipated benefits will be publicly released via the Internet. Therefore, do not include proprietary or classified information in these sections. Examples of past publicly released DoD SBIR/STTR Phase I and II awards are provided at https://sbir.defensebusiness.org/awards.

NOTIFICATION SCHEDULE OF PROPOSAL STATUS AND DEBRIEFS

Once the selection process is complete, the Army STTR Program Manager will send an email to the "Corporate Official" listed on the Proposal Coversheet with an attached notification letter indicating selection or non-selection. Small Businesses will receive a notification letter for each proposal they submitted. The notification letter will provide instructions for requesting a proposal debriefing. The Army STTR Program Manager will provide ***written*** debriefings upon request to offerors in accordance with Federal Acquisition Regulation (FAR) Subpart 15.5. All communication from the Army STTR PMO will originate from the program specialist's e-mail address.

DEPARTMENT OF THE ARMY PROPOSAL CHECKLIST

Please review the checklist below to ensure that your proposal meets the Army STTR requirements. You must also meet the general DoD requirements specified in the solicitation. **Failure to meet all the requirements may result in your proposal not being evaluated or considered for award**. Do not include this checklist with your proposal.

1. The proposal addresses a Phase I effort (up to **$150,000** for up to six-month duration).

2. The proposal is addressing only **ONE** Army Solicitation topic.

3. The technical content of the proposal includes the items identified in section 5.4 of the Solicitation.

4. STTR Phase I Proposals have four volumes: Proposal Cover Sheet, Technical Volume, Cost Volume and Company Commercialization Report.

5. The Cost Volume has been completed and submitted for Phase I effort. The total cost should match the amount on the Proposal Cover Sheet.

6. Requirement for Army Accounting for Contract Services, otherwise known as CMRA reporting is included in the Cost Volume (offerors are instructed to include an estimate for the cost of complying with CMRA – see website at https://cmra.army.mil/.

7. If applicable, the Bio Hazard Material level has been identified in the Technical Volume.

8. If applicable, a plan for research involving animal or human subjects, or requiring access to government resources of any kind.

9. The Phase I Proposal describes the "vision" or "end-state" of the research and the most likely strategy or path for transition of the STTR project from research to an operational capability that satisfies one or more Army operational or technical requirement in a new or existing system, larger research program, or as a stand-alone product or service.

10. If applicable, Foreign Nationals are identified in the proposal. Include country of origin, type of visa/work permit under which they are performing, and anticipated level of involvement in the project.

ARMY STTR 16.A Topic Index

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ARMY STTR 16.A Topic Descriptions

A16A-T001 TITLE: Chemical Kinetic Pathway Effects in Turbulent Reacting Flows

TECHNOLOGY AREA(S): Weapons

OBJECTIVE: Develop a methodology to assess the effects of turbulence-flame interactions on chemical kinetic pathways up to extinction and blow-out, and employ this methodology to develop tractable reduced chemical mechanisms for routine, large scale gas turbine combustor simulations that accurately capture these effects.

DESCRIPTION: To assess kinetic effects, detailed chemical mechanisms for gas turbine fuel surrogates have been developed [1]. These mechanisms are required to support a range of simulation activities that include fundamental kinetics research for surrogate and alternative fuel blends, and computational evaluation of advanced turbine combustor designs. Regarding turbine combustor assessments, detailed surrogate chemical mechanisms are too large for routine application. For example, the JetSurf Version 2.0 mechanism [1] includes 348 chemical species and 2163 chemical reactions. This type of mechanism is appropriate for kinetics research in reduced dimensional computational models. However, for realistic turbine combustor assessments, this detailed mechanism is much too large for deployment within a multi- dimensional flowfield simulation, especially in the context of large-eddy simulation (LES) approaches that are commonly used. For multi-dimensional simulations, detailed chemical mechanisms are reduced to form mechanisms that are tractable for a computational application, while retaining the general behavior of the detailed mechanisms. One approach to this reduction procedure includes several steps which are: 1) Selection of the skeletal mechanism from the detailed mechanism. 2) Selection of chemical species that may be assumed to be in quasi-steady state. 3) Implementation of the quasi-steady state assumption for species and reduction of the mechanism. Step 1 of this procedure is typically accomplished through researcher insight into the fuel mixtures to be investigated and the anticipated applications. Step 2 is accomplished either through researcher insight or through reaction pathway analysis [2]. Step 3 may be accomplished through automated numerical procedures (e.g., Lu and Law [3]) to complete the generation of a reduced mechanism. The reduced mechanism is then measured for accuracy against the skeletal and detailed mechanisms for reduced order problems [4][5]. In all cases, these problems are for laminar flows that do not include the interaction of chemistry with microscale turbulence. For example, reduced mechanisms are measured for accuracy for predictions of ignition delay times in homogeneous mixtures, laminar flame properties (i.e., species distributions and flame speeds), and laminar counter flow flame properties (i.e., species distributions with strain and extinction limits). A fundamental question regarding such reduced mechanism development is “Are chemical kinetic pathways altered by the interaction of micro-scale turbulence with flame structure?” The answer to this question has profound implications for the development of accurate reduced chemical mechanisms, and this question has not been significantly addressed [6]. For many years experimental investigations have observed differences in species production for laminar and turbulent flames (e.g., super equilibrium OH production in turbulent jet flames [7]). Such differences suggest that the interaction of turbulence with the flame structure may fundamentally alter the chemical kinetic pathways, especially as flame extinction is approached. If this is indeed the case, reduced chemical mechanisms developed for application to turbulent flows cannot be created based solely on the prediction of laminar flame properties. It is of fundamental importance to the US Army to assess the effect of turbulent interactions with chemical kinetics pathway especially in the context of high performance propulsion systems that operate under extreme conditions near the blow- out limit. Computational support for the development and assessment of such systems could be substantially limited if the chemical mechanisms that are applied do not properly account for the effect of turbulence-flame interactions that alter the chemical kinetic pathways. As a result, the Army desires a methodology to assess the effect of turbulence on chemical kinetic pathways, and use this information to systematically create accurate chemical mechanisms for turbulent flame simulations. Relevant fuels or surrogate fuels of interest to the Army should be considered. Close collaboration with academia is strongly encouraged to develop or identify appropriate detailed kinetic models and in order to leverage on innovative reaction mechanism reduction procedures arising from fundamental combustion research.

PHASE I: The Phase I effort will focus on the development and demonstration of a methodology or procedure to assess the effects of turbulence-flame interactions on chemical kinetic pathways. A plan should then be formulated to use this methodology to develop a computationally-tractable chemical kinetic mechanisms for routine application within large scale gas turbine combustor simulations.

PHASE II: Implement the plan identified in Phase I to fully develop an integrated procedure to generate tractable reduced chemical mechanisms that account for turbulence-flame interactions on chemical kinetic pathways. Apply and validate this procedure to a range of kinetics problems characteristic of gas turbine combustor flows.

PHASE III DUAL USE APPLICATIONS: For military applications, this technology is directly applicable to all high speed missile systems. This topic has direct application in both the military and commercial supersonic and hypersonic arenas. The most likely customer and source of Government funding for Phase-III will be those service project offices responsible for the development of advanced supersonic and hypersonic missile systems such as the Navy/DARPA HyFly, Air Force X-51, and DARPA Facet programs. However, it is possible that as NASA continues its access to space projects, this technology will become very important.

REFERENCES:
1. H. Wang, E. Dames, B. Sirjean, D. A. Sheen, R. Tangko, A. Violi, J. Y. W. Lai, F. N. Egolfopoulos, D. F. Davidson, R. K. Hanson, C. T. Bowman, C. K. Law, W. Tsang, N. P. Cernansky, D. L. Miller, R. P. Lindstedt, A high-temperature chemical kinetic model of n-alkane (up to n-dodecane), cyclohexane, and methyl-, ethyl-, n-propyl and n-butyl-cyclohexane oxidation at high temperatures, JetSurF version 2.0, September 19, 2010 (http://melchior.usc.edu/JetSurF/JetSurF2.0)

2. Tomlin, A.S., Turanyi, T. and Pilling, M.J., “Mathematical tools for the construction, investigation and reduction of combustion mechanisms” in Comprehensive Chemical Kinetics, Elsevier, pp. 293-437, 1997.

3. Lu, T. and Law, C. K., “Systematic Approach To Obtain Analytic Solutions of Quasi Steady State Species in Reduced Mechanisms,” Journal of Physical Chemistry A, Vol. 110, No. 49, pp. 13202–13208, 2006.

4. Sung, C.J., Law, C.K, and Chen, J.-Y., "An Augmented Reduced Mechanism for Methane Oxidation with Comprehensive Global Parametric Validation", Twenty-Seventh Symposium (International) on Combustion, The Combustion Institute, Pittsburgh, PA, pp. 295-304 (1998).

5. Montgomery, C., Cannon, S., Mawid, M., and Sekar, B., "Reduced chemical kinetic mechanisms for JP-8 combustion", 40th AIAA Aerospace Sciences Meeting & Exhibit, 2002.

6. Editorial Comment, Combustion and Flame, Vol. 159, 2012, pp. 2531 – 2532.

7. Seitzman, J.M., Ungut, A., Paul, P.H., and
Hanson, R.K., “Imaging and Characterization of OH Structures in a Turbulent Nonpremixed Flame,” proceedings of the Twenty-Third Symposium (Int.) on Combustion, The Combustion Institute, 1990, pp. 636 – 644.

KEYWORDS: turbulence, turbulent combustion, reduced chemical mechanisms

A16A-T002 TITLE: Solid State Additive Manufacturing of Titanium Alloys

TECHNOLOGY AREA(S): Materials/Processes

OBJECTIVE: Develop an additive manufacturing technology capable of processing titanium alloys via solid state joining.

DESCRIPTION: The U.S. Army’s light weighting initiative has resulted in the expanded use of titanium alloys in fielded armament systems. Due to the price of these alloys and their associated machining costs, the titanium components are very expensive to replace. Part refurbishment is a viable option to reduce these types of sustainment costs, and typically relies on the ability to deposit more material on the part in question – perfectly suited for additive manufacturing. However, the major problem with current additive processes is that the technology relies on fusing the new material to the old through melting and solidification. This ultimately leads to a high degree of distortion that usually results in the part falling out of dimensional specification and being rejected anyway. Due to this limitation, a solid state process is desired as the lower heat input will minimize this type of distortion. Additionally, the solid state process is capable of much higher deposition rates. This opens the possibility of expanding the process beyond part refurbishment and into complete near net shape fabrication.

PHASE I: Develop a solid state joining process that is capable of depositing titanium and its alloys for component repair or a near net shape build. The process must have a minimum deposition rate on the order of 20 lb/hour using either powder or wire feedstock. An open air system is preferable but a vacuum dependent system would be acceptable. The process must also have some degree of microstructural control. A process that has the ability for in-situ grain refinement is preferable, but one that limits grain growth is acceptable. All builds shall be subject to extensive characterization and logged in the DARPA Open Manufacturing Additive Process Schema. Deliverables shall be process development documentation in conjunction with materials property data on as deposited material.

PHASE II: Streamline the process developed in Phase I. Particular attention should be given to system automation. At completion of Phase II, the system should require no user input during the build cycle – tooling pathways must be computer controlled. If necessary, a process parameter feedback loop should be implemented to ensure build quality. Deliverables shall be process development documentation, build data logged in the DARPA Open Manufacturing Additive Process Schema, and the prototype system developed under this effort.

PHASE III DUAL USE APPLICATIONS: The material developed under this effort will have a myriad of applications in the military as well as the commercial sector. Of particular interest, component repair and direct part manufacturing are the key areas of interest. Direct part manufacturing would be a true enabling technology as custom tooling would be minimal to nonexistent. This is ideal for applications where a small quantity would be required. Such technology will bring a new level of capability to military as well as commercial consumers. Thus, the ultimate objective is a solid state additive manufacturing process capable of processing titanium and its alloys so as to maximize performance while minimizing the distortion traditionally associated with these types of repair.

REFERENCES:
1. W.M. Thomas, I.M. Norris, D.G. Staines, E.R. Watts, "Friction stir welding – process development and variant techniques," Proc. SME Summit, Milwaukee, WI, USA, August 2005.

2. I. Bhamji, M. Preuss, P.L. Threadgill, A.C. Addison, "Solid state joining of metals by linear friction welding: A literature review," Materials Science & Technology 2010, Vol. 27, No. 1, January 2011, pp. 2-12.

3. H. Kreye, "Melting Phenomena in Solid State Welding Processes," AWS Welding Research Supplement, May 1977, pp. 154-s – 158-s.

4. E. Brandl, A. Schoberth, C. Leyens, "Morphology, microstructure, and hardness of titanium (Ti-6Al-4V) blocks deposited by wire-feed additive layer manufacturing (ALM)," Materials Science and Engineering: A, Vol. 532, January 2012, pp. 295-307.

5. R.J. Friel, R.A. Harris, "Ultrasonic Additive Manufacturing – A Hybrid Production Process for Novel Functional Products," Procedia CIRP, Vol. 6, 2013, pp. 35-40.

KEYWORDS: additive manufacturing, titanium, joining, repair, refurbishment, solid state

A16A-T003 TITLE: Green Diode Lasers (480-550 nm Spectral Regime)

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: To develop longer wavelength visible diode lasers primarily aimed at green color wavelengths from 480 nm – 550 nm.

DESCRIPTION: Laser diodes are of significant interest to both the commercial and military sectors because of the compactness and potential high efficiency of their emission. Depending on their cavity designs, varying linewidths and output powers are possible for various applications. However, due to a variety of issues involving the growth of high quality epitaxial semiconductor materials in the green color optical bandgap regime (480 – 550 nm), green laser diodes have yet to be commercialized in the United States. Although much progress was reported after the DARPA VIGIL program [1-2], commercialization efforts shifted to overseas, and the wavelengths were primarily limited to 520 nm or less [3]. However, laser diodes spanning out to even longer wavelengths are of interest for applications in frequency doubling for UV laser emission in the 260 – 275 nm region [4]. The pursuit of such challenges has been studied with semipolar GaN substrates to minimize defect formation and increase the critical thickness for longer wavelength emission. Other approaches may be possible too using alloys of ZnO [5].

PHASE I: Study the growth, doping, and design of green laser heterostructures, particularly emphasizing the active region toward longer wavelengths than commercially available (520 nm – 550 nm). Feasibility analysis with supporting experimental data showing laser designs with emission powers of 100 mW at 480 nm and several mW or more across the green emission spectrum.

PHASE II: Pursue the full implementation of the ideas and initial growth runs done during phase I. Pursue growth of semiconductor alloys (likely InGaN with semipolar GaN substrates) with improved material quality and emission properties out to 550 nm. Goals would include 1 W emission power at 480 nm and 100 mW at 520 nm with at least 10 mW or more (continuous wave at room temperature) at 550 nm. Begin to evaluate reliability at various wavelengths and determine material related limitations and causes.

PHASE III DUAL USE APPLICATIONS: Continue to evaluate reliability across the wavelength spectrum to assess power output levels available and various applications of interest to military and civilian markets. Potential civilian applications include pico-projectors for miniature projection displays as well as potential use in head-lights and other lighting uses. The military uses could be several that include chemical and biological sensors that include integration with photonics integrated circuits or second harmonic generation for UV lasers from 240 – 275 nm, and the uses of UV lasers in a compact form factor are numerous from sensing to water purification to various forms of optical communications.

REFERENCES:
1. James W. Raring, et. al., "High-Efficiency Blue and True-Green-Emitting Laser Diodes Based on Non-c-Plane Oriented GaN Substrates," Applied Physics Express, 3, 112101, 2010.

2. J. W. Raring, et. al, "State-of-the-art continuous wave InGaN laser diodes in the violet, blue, and green wavelength regimes" Proc. SPIE 7686,76860, 2010.

3. Y. Zhao, et. al., "Indium Incorporation and emission properties of nonpolar and semipolar InGaN quantum wells," Appl. Phys. Lett., 100, 201108, 2012.

4. R. Kirste, et. al., "Properties of AlN based lateral polarity structures," Phys. Status Solidi C, 1-4, 2014.

5. K. A. Bulashevich, I. Yu. Evstratov, and S. Yu. Karpov, "Hybrid ZnO/III-nitride light emitting diodes: modelling analysis of operation," Phys. Stat. Solidi A, 204, 1, 241, 2007.

KEYWORDS: green laser diodes, semi-polar gallium nitride substrate, non-polar gallium nitride substrate, zinc oxide alloy

A16A-T004 TITLE: Acoustically/Vibrationally Enhanced High Frequency Electromagnetic Detector for Buried Landmines

TECHNOLOGY AREA(S): Sensors

OBJECTIVE: Develop a detector for landmines with enhanced performance based on linear and non-linear acoustic, vibrational, and electromagnetic (EM) combined effects.

DESCRIPTION: The rapid detection of buried landmines and discrimination from clutter remains a major problem for military tactical mobility, for soldier protection, and for humanitarian remediation of previously contested geographical areas. Traditional EM sensors for detecting buried landmines have used low frequencies (tens to hundreds of KHz) EMI (Electromagnetic Interference-metal) detectors and much higher frequencies (typically several GHz) for Ground Penetrating Radar (GPR). Recent results (refs. 1-2) indicated that the frequency range between the standard EMI and GPR detectors may offer advantages for the detection of landmines and landmine components, either in conjunction with a traditional sensor modality or separately. Older results (refs. 3-4) indicated that linear and nonlinear vibrational responses of landmines and other metal and non-metal buried objects could have distinct signatures which could be leveraged for detection and discrimination. Meanwhile other reports (eg. ref. 5) indicated that vibrations of a buried landmine or metal components can be sensitively detected by GPR operating at several GHz or lower in frequency.

PHASE I: Demonstrate by simulation and analysis the potential enhancement to be gained by leveraging the combined EM and vibrational effects on the signatures of buried targets for the purpose of detecting landmines and discriminating from clutter. Consider the EM frequency range from tens of KHz to several GHz. Consider linear and nonlinear vibrational and EM effects on the target signatures of the buried objects and any component parts (such as fuzing mechanisms). Consider the use of multiple or swept EM and/or vibrational frequencies. Determine the potential enhancement over published performance of current landmine detection systems in use. Design a detection system roughly within the size and weight footprint of the current AN/PSS14 (ref. 6). Design a component to create the vibration at the target. This may be either contained in the sensor itself or a separate component. There is no specified footprint for the separate component, other than that it must be compatible with tactical military mobility.

PHASE II: Explore with carefully designed experiments the optimum combinations of EM and vibrational effects for detecting landmines and their components and discriminating them from clutter. Experimentally verify the key results of the analysis in phase I. Develop signal processing embodied in software to exploit the advantages in target signatures. Develop a prototype system to include sensor, a vibrational component, and signal processing software package and demonstrate it in the laboratory and in field trials. Define in detail the path to commercialization, considering producing the system in-house, using external fabrication facilities for all or part of the production, licensing all or part of the technology to government contractors for landmine detection equipment or their commercial competitors, or selling directly to government program management offices. Consider military markets or marketing to non-governmental organizations (NGO's) involved in humanitarian or other remediation of mined areas.

PHASE III DUAL USE APPLICATIONS: Develop the packaging of the system compatible with the commercialization plan being pursued. Insure the packaging conforms to the expected uses and users environment. Consider other commercial applications, such as detection of buried plastic pipes. In the construction of houses, roads, sidewalks, utility infrastructure and maintenance activities buried metal pipes can be detected and avoided, but buried plastic pipes are often inadvertently cut or destroyed. Develop markets and address them.

REFERENCES:

1. Daniel C. Heinz, Michael L. Brennan, Michael B. Steer, Adam W. Melber, and John T. Cua, "High to very high-frequency metal/anomaly detector," Proc. of SPIE 9072, 907209 (2014).

2. Daniel C. Heinz, Michael L. Brennan, Michael B. Steer, Adam W. Melber, and John T. Cua, "Phase Response of High to Very High Frequency Metal/Anomaly Detector," Proc. of SPIE 9454, 94540H (2015).

3. Dimitri M. Donskoy, "Nonlinear vibro-acoustic technique for landmine detection," Proc. of SPIE 3392, 211 (1998).

4. Dimitri Donskoy, Alexander Ekimov, Nikolay Sedunov, and Mikhail Tsionskiy, "Nonlinear seismo-acoustic land mine detection and discrimination," J. Accoust. Soc. Am. 111, 2705 (2002).

5. Joshua M. Wetherington and Michael B. Steer, "Sensitive Vibration Detection Using Ground-Penetrating Radar," IEEE Microw. and Wireless Components Lett. 23, 680 (2013).

6. See the following web site:
http://www.marcorsyscom.marines.mil/portals/105/PDMENG/Docs/MOBS/B0476.pdf

KEYWORDS: landmine detection, electromagnetic induction sensors, EMI sensors, GPR, ground penetrating radar, vibrational detection, buried object detection, manufacturing landmine detection sensors

A16A-T005 TITLE: Overcoming RTOS Barriers to Deployment of Innovative Real-Time/Embedded Systems

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: To enable innovative multi-core real-time software systems to be developed without expensive, time-consuming, and hazardous modification of real-time operating system (RTOS) kernels.

DESCRIPTION: The advent of new multi-core computing platforms in recent years has brought with it the potential for deploying real-time/embedded systems with far more computational throughput than ever before. If leveraged properly, multi-core platforms could enable a new generation of “intelligent” systems, such as unmanned aerial vehicles (UAVs) and commercial robots. However, carrying out computational processing in a manner that efficiently and effectively utilizes multi-core platforms is a tremendous challenge. To a large degree, academic researchers have risen to this challenge, developing and testing a wide array of new techniques for real-time software scheduling and synchronization on multi-core platforms. These advances have far outpaced improvements in commercial real-time operating system (RTOS) offerings. Because modifying a commercial RTOS is hazardous, costly, and time-consuming for RTOS vendors and all but infeasible for RTOS users, this problem is likely to only grow in scope in the foreseeable future. In an effort to alleviate this problem, it is worthwhile to investigate methods for decoupling RTOS kernel services from real-time application scheduling and synchronization. Such a decoupling would allow application developers to make use of innovations from academia in multi-core software scheduling while still deploying software atop existing, unmodified RTOS kernels. The ultimate goal is a software package and/or library containing middleware and reusable software components that facilitate the described decoupling and that can easily be deployed by industry practitioners. Industrial practitioners would then benefit from the ability to select and deploy resource allocation techniques commensurate with their particular applications, rather than being “shoehorned” into the relatively “one-size-fits-all” traditional commercial/open-source RTOS software model.

PHASE I: In decoupling RTOS functionality from application-level scheduling functionality, a number of implementation choices must be made. In this phase, these choices should be formally categorized and analyzed using asymptotic techniques to illustrate their theoretical schedulability properties. Particularly promising techniques in terms of schedulability and synchronization when compared to results using existing RTOS should be identified.

PHASE II: In this phase, software packages to facilitate the methods of decoupling identified in Phase I will be developed and evaluated by comparing the performance of this decoupling on real-time scheduling applications to the performance of the same applications on existing RTOS. This comparison may be done in simulation but a significant performance enhancement over existing RTOS implementations needs to be demonstrated.

PHASE III DUAL USE APPLICATIONS: This project will result in reusable software components, easily deployed by developers, which enable the fielding of multi-core applications with innovative performance features. Such software components would be a valuable supplement to existing RTOS kernels and would potentially find use in myriad "intelligent" real-time/embedded systems deployed by both military and commercial interests.

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KEYWORDS: Multi-core processors, real-time software systems, real-time operating system kernels, decoupling kernel services, real-time scheduling and synchronization

A16A-T006 TITLE: Situational Awareness System

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Develop and deliver a stand-alone system for online threat detection and behavioral analysis for enhanced situational awareness.

DESCRIPTION: With the ever increasing number of social networking platforms and ensuing user-generated soft-data content, military-based intelligence is more than ever in need of a system to automate and streamline its collection, storage, analysis, and visualization capabilities and to incorporate this information into appropriate analyses for improved military intelligence assessment and soldier situational awareness.

Current intelligence gathering and analysis techniques are significantly human-labor driven for identifying, searching, discovering, and analyzing content on various web sites. Worst case, results are inefficient, incomplete, and disorganized, resulting in dubious outcomes, and in the best case are so labor intensive they can be inaccurate because they are based on outdated stale data. Recent technological and methodological developments in data science allow technically advanced users to scrape [1] massive quantities of data with modest effort from sources like Twitter and WordPress [2,3]. Likewise, advancements in processing textual data via social network analysis [4], natural language processing [5], and graph visualization for community detection [6,7] allow skilled users to explore and analyze big data. However, such advanced techniques are only accessible to highly skilled, technically savvy people. To make use of such data for enhanced situational awareness by a greater number of people, we need to bring together various methodologies to develop a comprehensive, scalable, user-friendly system to (A) collect, (B) store, (C) analyze, and (D) visualize public data.

The first challenge (collect) is to create a simplified process, allowing non-technical end-users to select from one or more public sites for data scraping based on a set of input parameters (e.g., name, timeframe, keywords, hashtags) [1]. The second challenge (store) is to create an organizational system flexible enough to store variable datatypes stemming from a plethora of data sources including yet to be created social media platforms. The third challenge (analyze) is to design and leverage existing algorithms for data analysis. Analysis capabilities must include, but are not limited to, social network analysis of single graphs and multi-graphs; flow analysis to assess information cascades throughout the network; individual-level behavior pattern analysis with the capacity to identify behavioral changes, and community detection [6,7]. Additional analysis capabilities should incorporate the latest analytic capabilities based on language analysis such as deception detection [8] and indicators of hierarchical positioning [9]. The fourth challenge (visualize) is to create scalable visualization techniques that will allow the user to explore individual profile information; fluidly visualize single or multimodal network graphs; drill through graphs to uncover the underlying data; and show how individual behavior patterns change over time (e.g., frequency of tweeting; length of blog posts) [6].

The implemented system will have a small form factor that is multiplatform, portable, and scalable. The system will provide the ability to choose multiple algorithms for analysis based on user needs. Additionally, the GUI must be turnkey, with an easy to use interface for non-technical end-users. The system will contain a searchable database with available communications from multiple sources such as Twitter, Facebook, LinkedIn, and blogs, and should allow for multiple data types such as text, pictures, audio, and video. All stored data must retain relevant meta-data like sender, receiver, date, time, and geo-tags. The system should provide efficient analysis capabilities including the ability to create search profiles, custom categorizations – both emergent and pre-defined, identification of behavior patterns (e.g., an individual posts most frequently during late night hours), and identify changes in behavior patterns (e.g., individual suddenly posts in afternoon).

PHASE I: The Phase I effort will address the first two challenges by developing and demonstrating a prototype system capable of running from a portable device with an intuitive user interface that will allow for data scraping from multiple sources based on a single set of input parameters. The prototype solution must be capable of running off a stand-alone USB drive without the need to install files on the host machine; moreover, the software should not connect to central server for data storage or processing (that is, no cloud-based solutions will be accepted). The software tool should be designed in a manner to aggregate disparate data types from a variety of sources and be modular in design so it can be easily updated as social network companies release new or change APIs. The specific data to be scraped should be driven by an informed military need.

PHASE II: The Phase II effort will address the third and fourth challenges by concentrating on the design and development of analytic capabilities to create a composite picture from multiple data sources and providing informative, scalable visualization capabilities for both data and analytics. Additionally, indicate and flag changes in behavior based on communication patterns obtained through different social media inputs. In addition, Phase II will develop valid social network link prediction analytics and community structure analysis tools. The offeror must demonstrate a clear understanding of analytics relevant to military needs.

PHASE III DUAL USE APPLICATIONS: Phase III efforts will be directed toward refining a final deployable design with sophisticated, cross-platform GUI; incorporating design modifications based on results from tests conducted during Phase II; and improving engineering/form factors, equipment hardening, and manufacturability designs to meet U.S. Army Concept of Operations (CONOPS) and end-user requirements.

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KEYWORDS: Social Media Data, Social Network Analysis, Network Visualization, Text Processing, Public Data Scraping, Enhanced Situational Awareness

A16A-T007 TITLE: Quantification Model and Systems for Assessing and Developing Resilient Wireless Communication Operation

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: The objective is to create a highly effective and accurate system that can identify stealthy wireless attacks. This topic will enhance the resiliency of Army and DoD cyber operations through better response to intrusions and more effective mitigation of attack impacts

DESCRIPTION: Wireless systems are important part of DoD operations, for both tactical and strategic applications. New capabilities such as unmanned vehicles or unmanned weapon systems are critically dependent on highly trusted and reliable wireless communications. However, due to the open communication of wireless communication, the system is subject to a wide range of external effects, ranging from environmental impact to malicious human attacks, especially silent attacks, such as carrier-sensing attacks, signal emulation, and radio interference are posing more challenges. With a much smaller footprint, many smart attacks can be easily blended in without being detected. The net consequence is that our wireless systems are seemingly working fine from network setup and operation perspective, but users/systems experience delays and information loss, leading to degraded mission execution capability.

It is critical that we establish a formal quantitative analysis models that can be used to predict, assess and analyze impact assessment of wireless systems. Such quantitative model and its associated benchmark will guide us to create effective detection systems, and design attack resilient wireless systems that can sustain critical missions. This topic seeks the development of advanced wireless quantification techniques as well as novel attack detection and defense frameworks that account for a broad scope of the attack space in a tactical network environment. The development should consist of both theoretical modeling and realistic hardware-in-the-loop experimentations with unique test and evaluation capabilities that can be provided by high fidelity radio frequency network channel emulators. The effectiveness of defense techniques should be thoroughly validated in hardware based experiments under realistic dynamic tactical scenarios.

PHASE I: Establish performance and resiliency models and quantification metrics for wireless system that are subject to stealthy attacks. Create proactive defense mechanism which include attack detection and dynamic maneuvering to identify potential threats and to mitigate their impact.

PHASE II: Develop an attack quantification and defense prototype system that can demonstrate the capability of attack detection, measurement, quantification, and proactive defense. Detection system efficiency and accuracy need to be verified not only in NS-2 type of software based simulation, but also through wireless network emulator that contains physical layer setup including true over the air RF waveforms, and that can replicate relevant and complex networking environment, such as multi-hop communication, multiple spectrum channels, radio interference, mobility, multi-path, and Doppler effects.

PHASE III DUAL USE APPLICATIONS: Further develop and mature the prototype system and reach TRL-6. Demonstrate the working prototype in an operationally relevant environment. Define, finalize, and execute the transition and commercialization plans such that the detection systems can be field tested.

DUAL-USE APPLICATIONS: Wireless defense technology has direct application in commercial communications, such as cellular communications, Wi-Fi and mobile cloud systems, sensor and vehicular networks, and satellite communications. In addition, related cyber defense capabilities could greatly enhance performance and resilience of public safety and emergency communications systems and support interoperability of other emerging wireless systems over unlicensed spectrum.

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KEYWORDS: wireless attacks, quantification, measurement, emulation, defense, wireless networking

A16A-T008 TITLE: Field Drug Identification Kit

TECHNOLOGY AREA(S): Chemical/Biological Defense

OBJECTIVE: Development of an easy to use, field-rugged drug identification kit.

DESCRIPTION: Illicit drug trafficking is a key source of financing for terrorist organizations, and as a result, the U.S. Army plays an active role in countering illicit drug trafficking. Soldiers and military police are often tasked with identifying illicit drugs in difficult and demanding field environments. Sophisticated electronic devices for detecting drugs do exist, however, these devices are typically expensive, bulky/heavy, non-ruggedized, and require a high level of training. Microarray chips for label-free detection have been investigated to improve selectivity and potentially reduce the overall size, weight, and power of the detection platform but may not be robust enough for relevant operating environments [1]. Colorimetric chemistry has been demonstrated to be an easy, cost effective approach for drug detection and identification [2], but current colorimetric field detection kits are typically limited to detecting only a single class of drugs. Advances in chemometric pattern recognition [3] have resulted in the development of sensitive and selective sensor arrays for the identification of complex mixtures of both volatile organic compounds and aqueous solutions of organic compounds [4,5]. Development of a novel detection platform that exhibits enhanced sensitivity and specificity over current test kits and avoids the need for bulky and complex instruments is desired.

The U.S Army specifically has an unmet need for a drug identification kit that is capable of detecting all major illicit drug classes in a single test as existing field tests have a number of drawbacks (multiple levels of testing required; hazardous materials contained in test matrices; subjective interpretation of data output). As there are currently no reliable fielded technologies to detect the synthetic cannabinoids, the ability to distinguish this class of drugs is of particular interest and will be a distinguishing feature for submission.

The proposed solution should be: easy to use; low cost (no more than $15 per test); lightweight; no or low power (i.e. consumer batteries); physically rugged; operable in a wide range of field conditions; exhibit a shelf life of at least 1-2 years; and require minimal user training. The proposed solution must exceed performance (sensitivity, specificity) of currently available test methods, reducing operator/analysis steps, and reduce false positives from common household and industrial materials. The proposed form factor must support ease of use, portability, meet military specifications, and ensure environmentally safe disposal of any testing materials. Ideally, the solution would interface with existing deployed communication devices (i.e. tablet, mobile device) to power solutions and report output.

PHASE I: Develop, test and/or demonstrate a detection platform capable of detecting synthetic cannabinoids (e.g. JWH-018, XLR11, AB-PINACA) and opiates (e.g. heroin, codeine, morphine, hydrocodone, oxycodone). Test results are required in less than 5 min. Conduct preliminary stability testing on the detection mechanisms/chemistries to indicate potential suitability for field use. Develop a prototype concept capable of achieving all of the performance requirements listed in the description above.

PHASE II: Incorporate detection mechanisms/chemistries from Phase I into the prototype design from Phase I. The prototype must be capable of detecting all listed classes of drugs from Phase I plus phenethylamines (e.g. amphetamines, methamphetamine, MDA, MDMA, ephedrine), cathinones (e.g. Novel Psychoactive Substances (NPS) cathinone, butylone, methylone), and hallucinogens (e.g. LSD, mescaline, psilocin, psilocybin, bufotenine) in a single test in less than 5 min. Demonstrate use under a range of operating and storage temperatures (2-50 degrees Celsius) and humidities (10-95% RH). Demonstrate a kit shelf life of a minimum of 1 year at room temperature. Demonstrate prototype in a realistic environment.

PHASE III DUAL USE APPLICATIONS: This technology has a broad range of potential civilian and military applications. The detection platform for various classes of drugs can be extended to intelligence operations, law enforcement, and first responders.

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KEYWORDS: Narcotics, Illicit Drugs, Sensitive Site Exploitation, Field Kit

A16A-T009 TITLE: Metamorphic Buffer Layer Growth for Bulk InAs(x)Sb(1-x) LWIR Detectors

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Development of metamorphic buffer layers on commercially available IIIV substrates (GaAs or GaSb) for the growth of high quality III-V BULK material based long-wavelength infrared (LWIR) nBn detectors.

DESCRIPTION: Advantages from improved uniformity and increased process yields of III-V detector materials are being realized in the mid-wavelength infrared (MWIR) via device structures that incorporate a unipolar barrier layer. MWIR devices incorporating these barrier structures are now becoming commercially available in high operating temperature (HOT) and HD formats.1 The devices employ an Al As(x) Sb(1-x) based alloy for the unipolar barrier to block majority carriers and surface leakage current, as well as suppress generation-recombination current.2 Incorporation of narrow gap InAs(x)Sb(1-x) in a unipolar barrier architecture with an Al(x)In(1-x)Sb barrier layer could enable realization of these advantages for bulk long-wavelength infrared (LWIR) detectors.

Unlike strained layer superlattice (SLS) structures, bulk InAs(x)Sb(1-x) has the advantage of high, isotropic hole mobility. As such, it presents an avenue to achieve longer carrier diffusion length resulting in high quantum efficiencies with n-type device architectures, such as the nBn. Another advantage of InAs(x)Sb(1-x) is the potential to produce bulk material with a spectral cutoff out to nearly 12.5 ?m. This was revealed in a recent study that showed a narrower than previously thought band gap for InAs(x)Sb(1-x). The study attributed the narrow band gap to large band bending for the InAs(x)Sb(1-x) alloy.3 Incorporating narrow gap InAs(x)Sb(1-x) into a unipolar device architecture will require the identification and optimization of a metamorphic buffer layer to transition from a commercially available substrate to the lattice constant of the InAs(x)Sb(1-x) detector material. InAs(x)Sb(1-x) absorber layers have been grown on GaSb by Wang et al.4, and GaAs by Lubyshev et al. 5 utilizing various metamorphic buffer layer schemes with encouraging results.

The relative simplicity of processing detectors based on the nBn device structure will enable rapid adoption by commercial foundries. Commercial III-V foundries including material growers should be able to use these recipes to develop advanced high resolution LWIR FPAs with enhanced performance suitable integrate with U.S. Army and DoD systems giving the tremendous advantage to U.S. Warfighters. Commercial applications of devices based on bulk InAs(x)Sb(1-x) include medical diagnostics and therapeutics, chemical and pollution sensing, materials processing, industrial process monitoring, food safety monitoring, aircraft anti-missile warning/protection and combustion diagnostics for high efficiency power generation. DoD applications include infrared countermeasures (IRCM), detect/locate hostile fire, detect/negate hostile imagers, sensors for persistent surveillance, helicopter landing during brownout, missile warning, and detection of explosive and chemical warfare agents.

PHASE I: Develop a plan to identify the best substrate and metamorphic buffer material combination(s) to reduce stress and/or strain in subsequently grown bulk InAs(x)Sb(1-x) layers. Following identification of the potential substrate/metamorphic buffer layer material system(s), develop a systematic material growth and characterization plan. The characterization plan should include techniques capable of imaging individual defect types as well as assessing the overall density of defects in the InAs(x)Sb(1-x) layer. It is strongly encouraged that the work be conducted in collaboration with a commercial epitaxy vendor to increase the potential for commercialization of bulk LWIR devices based on this effort. Demonstrate growth of bulk InAs(x)Sb(1-x) with a spectral cutoff > 11.5µm on a commercial substrate, and provide a sample to the Army for characterization.

PHASE II: Optimize the growth of the metamorphic buffer layer to minimize the density of active defects in the bulk InAs(x)Sb(1-x) to demonstrate LWIR nBn devices with a spectral cutoff > 11.5µm. Demonstrate growth of nBn device structures incorporating the optimized metamorphic buffer layer and bulk InAs(x)Sb(1-x) absorber. Collaboration with commercial infrared imager foundries for device structure development and characterization is strongly encouraged to support the commercialization of the bulk InAs(x)Sb(1-x) detector material.

PHASE III DUAL USE APPLICATIONS: The contractor shall pursue commercialization of the technology developed in Phase II for potential commercial uses in such diverse fields as law enforcement, rescue and recovery operations, maritime and aviation collision avoidance sensors, medical uses, homeland defense, and other infrared detection and imaging applications. The technology will be developed as product or growth recipes that can be licensed or transferred and utilized with limited expertise, irrespective of the commercialization route. Commercial III-V foundries including material growers should be able to use the product or recipes to develop advanced high resolution LWIR FPAs with enhanced performance suitable to integrate with U.S. Army and DoD systems. Successful demonstration of this technology will lead to insertion in systems for next generation forward looking infrared detectors, and provide important leap ahead wide area persistent surveillance systems and infrared search and track capabilities for the Warfighter including Army tactical systems like the Javelin. The successful development of high uniformity LWIR nBn detectors based on III-V material will immediately improve the performance of systems requiring advanced high performance infrared sensors by reducing size, weight, and power consumption requirements as well as cost.

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KEYWORDS: Infrared detectors, InAs(x)Sb(1-x), long wavelength infrared (LWIR), material growth, metamorphic buffer layer, nBn, III-V antimony based material, unipolar barrier

A16A-T010 TITLE: Tactical Immune System (TIS)

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Natural biological immune systems protect animals from dangerous foreign pathogens, including bacteria, viruses, parasites, and toxins. Their role in the body is very analogous to that of computer/cyber security systems in computing. Although there are many differences between living organisms and computer systems, we believe that the similarities are compelling and could point the way to improved computer/cyber security in the tactical environment. The analogy with immunology contributes an important point of view about how to achieve computer/cyber security, one that can potentially lead to systems built with quite different sets of assumptions, biases, and organizing principles than in the past. A Tactical Immune System capability needs to be researched and developed to be able to accurately identify self, defend against “non-self” threats through self-healing properties, and re-align baseline definition of self once threats are eradicated.

DESCRIPTION: Immunologists have traditionally described the problem solved by the immune system as the problem of distinguishing "self" from dangerous "other" (or "non-self") and eliminating dangerous non-self. The problem of protecting computer systems from malicious intrusions can similarly be viewed as the problem of distinguishing self from non-self. Non-self might be an unauthorized user on a tactical radio, foreign or unanticipated code on a tactical node or information system, or data that cannot be verified from a confidentiality or integrity perspective - which can coincidentally negatively affect a critical mission. What would it take to build a computer immune system with some or all of the properties of a natural immune system for the tactical environment? It might have at least the following basic components: a stable definition of self, prevention or detection and subsequent elimination of dangerous foreign activities (infections), memory of previous infections (compromises/information pilferage attacks), a method of recognizing new infections, and a method of protecting the immune system itself from attack. The field of Autonomic Computing which investigates principles of self-management, self-healing, and the like serves as a viable baseline for exploring immune system principles at the tactical edge. The goal of this effort is to investigate the potential of applying the aforementioned immune system principles to a representative tactical system or set of systems comprising a network environment. This solution will provide a confident level of security for the target tactical systems without relying on a full blown network-based infrastructure for application of patches (and similar) and the recovery from new threats.

PHASE I:
1. Research existing schemes (government, industry, or academia) for characterizing a Tactical Immune System (TIS) for an enterprise and tactical environment.
2. Identify target tactical platforms and network environments for incorporating TIS concepts.
3. Identify potential areas of applicability of TIS concepts on deployed or soon to be fielded tactical systems.
4. Design proof of concept TIS for target tactical platform(s) to demonstrate its feasibility. The concept should consider best practices based on government, industry and academic standards to enable use in the Army's Common Operating Environment (COE).
5. Produce a detailed research report outlining the design and architecture of TIS, as well as the advantages and disadvantages of the proposed approach.

PHASE II:
1. Based on the results from Phase I, execute design of and implement a fully functioning prototype solution for an autonomic Tactical Immune System (TIS) geared towards protecting identified tactical systems.
2. Provide test and evaluation results that demonstrate the value of the TIS to the target tactical platforms.
3. Develop a final report for Phase II describing the specific concepts of a TIS (e.g. self designation, we were able to design, implement, and test within actual tactical environments).

PHASE III DUAL USE APPLICATIONS:
1. Further develop prototype into a transitional product with necessary documentation and test results for a Program of Record such as the Nett Warrior (NW), Program Execution Office (PEO) Soldier for integration into their environments or target Ground Soldier Systems (GSS).
2. Socialize prototype and overall concept to other US defense Programs of Record and commercial implementations to identify additional areas of applicability for TIS and associated concepts.

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KEYWORDS: immune, pathogen, cyber security, tactical, attack, autonomic, self-healing, computer

A16A-T011 TITLE: Nadir-Looking Synthetic Aperture Radar (NadirSAR)

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation.

OBJECTIVE: Develop very-high-resolution (as fine as 0.1 m) three-dimensional imaging techniques that will allow current and future Army microwave/millimeter wave synthetic aperture radars (SARs) to detect and identify targets in urban canyons, concealed under foliage, and other challenging environments using data collected with circular flight path trajectories.

DESCRIPTION: SAR is a principal sensor for collecting ISR data under all weather conditions and at all times of day from stand-off geometries. The Army currently has several microwave systems that provide valuable ISR information in open environments (i.e. environments in which the targets are not concealed under foliage or placed in areas containing many large structures). Conventional SARs fly straightline flight paths when performing their mapping functions.

Recently circular flight path SAR imaging techniques have been developed and demonstrated that can perform 360 deg imaging of targets, providing multiple aspect angle images of areas of interest that contain much greater detail than conventional, single look angle SAR images.

The objective of this topic is to extend the circular SAR imaging concept for imaging at very steep grazing angles (e.g. 70 to 85 degs). The objective of imaging at such step angles is to provide the SAR with the ability to peer into urban canyons and to penetrate some types of foliage by looking near-vertically through the branches instead of through the tree stems. For such imaging geometries, the cross-range SAR resolution remains that provided by the synthetic aperture length. However the range resolution will now provide target height information. The third dimension of range resolution, which would become a function of the elevation beamwidth of the antenna for the steep look-down geometry, must be achieved through an innovative processing technique. Such techniques could include the coherent processing of the circular trajectory data, tomography, interferometry, etc.

The microwave SARs that are currently used or that are being contemplated by the Army have only a single receive aperture. The algorithms and imaging techniques that are to be developed must be compatible with such systems. Also, while multiple orbits can be flown about an area of interest to form the NadirSAR images, operational constraints will favor those concepts that can provide the three-dimensional imagery in the minimum time.

Finally, there is currently no collected data available to support this effort. While the use of synthetic data is permissible, stronger research proposals would include data collections using SARs that can be made available and suitably modified for NadirSAR imaging.

PHASE I: The objectives of the Phase I program are to: 1) verify through simulation, analysis, etc., a concept for forming NadirSAR images, and 2) generate a Phase II program plan for simulating and/or collecting and processing the data. The Phase I effort should establish the fidelity of the simulation, the SAR parameters, the navigation requirements for the aircraft, and other such key factors relevant to the Phase II program.

PHASE II: The objectives of the Phase II program are to: 1) simulate and/or collect the NadirSAR data, 2) quantify the quality of the imagery that is formed (e.g. resolution, MNR, artifacts), and 3) demonstrate the ability to form three-dimensional SAR images of targets that are hidden in urban canyons, concealed under foliage, and placed in other challenging conditions. The demonstration of real-time imaging is not required.

PHASE III DUAL USE APPLICATIONS: NadirSAR should be a very useful capability for both military and civilian applications. The enhanced microwave SAR capabilities will allow military requirements such as detecting targets concealed under foliage to be achieved with existing systems, thus removing the need for additional, low-frequency SARs. Relatively minor modifications to existing equipment to support steep grazing angle imaging will probably only require minor hardware changes. Civilian support missions could include disaster relief (e.g. imaging rubble piles after earthquakes, searching for victims in forest and jungle areas), or detecting illicit/terrorist activities being conducted in challenging environments.

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KEYWORDS: Synthetic Aperture Radar, Circular Imaging

A16A-T012 TITLE: Man-Portable and Fieldable Mass Spectrometer for Sequencing Peptides

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: Develop a new miniaturized multi-order (MSn) mass spectrometer that is man-portable and capable of detecting and sequencing peptides derived from biological agents including bacteria, viruses, and toxins.

DESCRIPTION: Currently our ability to detect biological threats in the field relies heavily upon immunological based assays which have limited robustness, specificity, and often generate false positive results. Although mass spectral techniques exist which have high sensitivity, high selectivity and are broadly applicable for detection and identification, the research grade instrumentation used has a large physical and logistical footprint making it impractical to bring into the field. Several efforts have been made over the last decade to miniaturize mass spectrometers for the detection of chemical warfare agents (CWA)3, toxic industrial chemicals (TICs), and illicit drugs4. From these investments, several portable mass spectrometry (MS) systems have been successfully commercialized demonstrating both the feasibility and utility of a miniaturized mass spectrometer. At present there is a need to develop a new portable multi-order mass spectrometry system that can sequence peptides derived from biological agents including bacteria, viruses, and toxins. Prototypes/designs of portable backpack systems have been published and tested, but a fully functional system with the specifications needed for peptide sequencing have not been realized1,2. This system should have a broad mass range (such as 300-1600 m/z), adequate mass resolution (~3000 <1.0 Da, FWHM; Full Width at Half Maximum), reasonable dynamic range with moderate sensitivity (detecting sub-ug amounts in complex matrixes) and it should be capable of performing multiple data dependent MS/MS scans. This type of new instrumentation should be flexible in design so that it can be coupled with the current state-of-the-art in sample preparation and/or liquid chromatography, ESI/ambient ionization, and data processing algorithms. Furthermore, the analysis and data handling systems should be designed in a way that, once completely mature, could be operated by a non-expert with minimal training. Should a system be successfully designed it could easily replace the current state-of-the-art MS-based chemical detection primarily due to its superior capabilities. Potential customers for a commercialized system span a wide range of government agencies and commercial entities including the military, the department of homeland security, first responders, and hospitals.

PHASE I: During Phase I performers will provide evidence that each of the principle components are physically validated or have been shown to work as proposed in a different instrument systems. This includes each critical component potentially including but not limited to the sampling, sample preparation, chromatographic, atmospheric MS inlet, ion optics design, mass analyzers, pumping system, and electrical/computer system (i.e. sampling through data interpretation). In addition, preliminary evidence using a simulation program such as SIMION should be provided supporting the feasibility of the overall marriage of all components. Initial efforts during the Phase I of this program should be focused on generating evidence that all components of the proposed system work together in unison. Less attention needs to be given to the strict logistical requirements of this breadboard instrument including weight and power requirements. However, performers that demonstrate the potential to acquire data that results in sequenced peptides from a complex mixture such as a tryptically digested cellular lysate will be preferred for transition from Phase I to Phase II.

PHASE II: Candidates that are awarded a Phase II proposal shall further develop the instrument into a pre-production prototype that can be tested in a relative environment outside of a laboratory setting. The pre-production prototype shall strive to meet the following criteria:
• A complete system weighing approximately 40 lbs
• Total volume/size is amenable to being carried on a backpack or a suitcase no larger than a “carry-on” bag. Battery pack could be designed so that it is in a separate case. Capable of operating or charging with solar power is a plus! Having the power supply designed as a separate module could allow for easy “upgrades” as the design (instrument and power supply) evolves and matures.
• Minimal power requirements so that it is capable of running on battery power at least for a brief period of time. This is preferred, but not required.
• MS resolution of ~3000 FWHM
• Capable of multiple data dependent MS/MS scans
• Sensitive enough to detect infectious dose quantities

PHASE III DUAL USE APPLICATIONS: Should the breadboard pre-production prototype successfully meet all criteria set forth during the Phase II effort, multiple prototypes shall be constructed and distributed to at least three different laboratories for independent validation. These independent groups could span both academia, government, and another potential commercial transition partners with significant resources and customer base amendable to launching a successful a production and marketing campaign. It is expected the bulk of the software development will be performed in this phase. Up to this point it is acceptable that the instrument control and data analysis be performed by highly trained personnel. However, in the final product sample gathering, preparation and analysis as well as spectral interpretation will need to be simplified for use after moderate training (2 weeks). Additionally, this phase can be used to improve logistical characteristics such as weight and power consumption. For example, weight could be reduced by replacing heavier but more inexpensive materials with lighter but expensive ones (stainless steel parts with titanium). This product would fulfill needs across a wide customer base including medical facilities, first responders, and private practices to aid in diagnosis. It would be extremely beneficial across all branches of the military for both threat detection and diagnosis. The FDA and EPA would find a high resolution mass spectrometer very useful for compliance regulations.

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KEYWORDS: Miniaturized, mass spectrometer, bio-detection, portable, chemical detection, MSMS, BW

A16A-T013 TITLE: Beliefs, Values, Interests and Practices of Identities, Networks, Groups for Planning & Analysis

TECHNOLOGY AREA(S): Human Systems

OBJECTIVE: Using open source data, characterize population identities and interrelationships in terms of beliefs, values, interests and practices, and detect, quantify, track and provide analytical tools.

DESCRIPTION: To protect national interests and effectively plan, coordinate and execute military operations, support training and foster partnerships, the U.S. military must better understand populations involved in or impacted by operations. Well-publicized challenges of operating in and amongst the peoples across the globe, including but not limited to the Middle East, Africa, Eurasia, and Southeast Asia, and the consequences of our military operations have highlighted the criticality of better understanding and incorporating cultural, behavioral, and demographic considerations in plans. These considerations are critical for: (1) meaningful assessments of progress towards tactical, operational and strategic objectives; (2) supporting analysis of changing population patterns to discover emerging issues or evolving relationships; (3) guiding decisions about maneuver through one area or another; (4) understanding key leaders and constituent stakeholders; (5) site selection and design considerations for contingency bases; (6) finding better partnership methods or opportunities; and many other issues.

The U.S. Army Operating Concept [1] states that, "to compel enemy actions requires putting something of value to them at risk," (p. iii) and that, "future enemies will act to remain indistinguishable from protected populations," while "Army forces [must] possess cross-cultural capabilities that permit them to operate effectively among populations" (p. 18). The Army must enable effective integration of multinational efforts, in contested environments (p. iv). The concept emphasizes the significant impact of, "Increased velocity and momentum of human interaction and events requires forces capable of responding rapidly in sufficient scale to seize the initiative, control the narrative, and consolidate order" (p. 11). The "Army Vision - Force 2025" [2] provides that "Reduce surprise" is a key line of effort, and continues noting, "Small unit leaders will be decentralized... and required to process large amounts of information... [and] the Army should exploit ways to reduce... cognitive burdens to enhance Soldiers' ability to perform in these challenging environments" (p. 6).

When fully addressed, this challenge requires historical, as well as up-to-date, dynamic and interacting population data, in order to support analytical tools that can help expose insights into population drivers and relationships. The resulting capability will also support the U.S. Army Functional Concept for Engagement [3], which notes the importance of, "understanding the relationships between actors and influencers, their allegiances and behaviors, and trends that shape their interaction, will be critical to understanding the complexity of the operating environment" (pg 10).

Relevant data about diverse beliefs, values, interests and practices, associated with identities, groups and collectives could conceivably be derived from any number of potential unclassified sources to include surveys, experimental data, biophysiological data, books [4], print and broadcast media [5], social media [6], peer-reviewed publications [7], economic and agricultural data, subject matter expertise, blogs, interviews, opinion columns, general websites, photographs, aerial imagery, massively multiplayer online games, chat forums, or many other resources. The U.S. Army requires such data be accessible, historical and current, fused, modeled, and made meaningful to Army personnel at the appropriate echelons with suitable, innovative analytic tools. Appropriate representational forms could include dynamic maps [8], network graphs [9], other conventional, novel or combinatorial forms, to include integration potential with other relevant mission data.

While 'big' social and cultural data offers promise for analysis and situational understanding [10], it also imposes significant challenges. Architectural and collection issues, updating data, data storage and processing requirements, privacy considerations, incongruities of data forms and scales, source material trustworthiness and reliability, and vastly varied availability of data are just some of the challenges impacting this topic. Although population impact planning presents a canonically wicked problem [11], analysis of groups and their associated beliefs, values, interests and practices has been demonstrated to be valuable for specialized military and intelligence analyses [12, 13], as well as within the private sector especially for marketing, advertising and product design. Such analyses has conventionally been successfully conducted by skilled experts on very narrow, focused topics.

This topic seeks to provide automated or semi-automated innovative approaches to organizing and exposing meaning from messy data, with tools to support collection and processing of big open source data, and yield meaningful focused analytical products.

PHASE I: In order to successfully address this topic, Phase 1 proposals are expected to address challenges including: (1) a means for identifying, collecting, updating and storing appropriate raw data for a topic of study using secure protocols; (2) mitigating incongruities across data sources and processing data into appropriate data representations with useful scoring methods; (3) how to inference across data and approximate information about identities, groups, organizations, networks and collectives, along with associated beliefs, values, interests and practices; (4) representations and analytics that make the data and derived information sensible; (5) measures of success and improvement for such data, tools and analytical findings.

Phase 1 deliverables are expected to include: (a) a documented conceptual design characterizing the technical method, services, tools and techniques to be implemented to collect data, perform processing and provide user-facing analytics; (b) outline and document exemplary sources, data, analytical examples and mock-up solutions for militarily-relevant topics; (c) define metrics and performance goals to be used for assessing progress towards accurate and appropriate processing (including validation and verification strategies) as well as estimating confidence, uncertainty and relevance for processed data; (d) document and report findings of pilot studies into the proposed conceptual design and technical implementation including metrics and initial performance estimates.

PHASE II: At the end of Phase II, a budget activity 6.2 effort, the expected result will be the construction and demonstration of a prototype with a technology readiness level of between 4 and 5. It is expected the prototype will have demonstrated relevance through limited user tests with Army stakeholders, and is expected to require additional funding for further military development and integration. Expected Phase II deliverables include: (a) an experimental prototype that has been demonstrated as functional, feasible and relevant on Army research and development networks with a diverse range of open sources; (b) detailed specifications for further development requirements including proposed additional sources, computer and human interfaces, algorithm enhancements resulting in improved computational processing and reduced cognitive load; (c) analyses of experiments to assess functionality and feasibility of the prototype, along with metrics to assess U.S. Army relevance and performance; (d) documented initial integration plans; and (e) technical documentation of the prototype, configuration, machine and user interfaces, data, extensibility and known limitations of the prototype (e.g., processing or storage capacity, coverage, etc.).

PHASE III DUAL USE APPLICATIONS: At the successful conclusion of Phase III, the capability is expected to have commercial use for international marketing and business, especially market and social network analysis, and potentially organizational culture [14]. It is also expected to result in a capability relevant to multiple program offices across the Department of Defense and have applications for the intelligence community. The capability is expected to support fusion across multiple intelligence sources, and include future extensibility through maximized use of open data models and software standards, and provide application programming interfaces to efficiently support the evolving information environment. The ultimate capability is expected to capture, quantify and model information (past and present, vetted and unvetted) about the many types of affiliations with which people in a region (physical, conceptual and virtual) may identify, and how those identities relate with respect to beliefs, values, interests and practices.

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KEYWORDS: Human, Identity, Fusion, Analysis, Narrative, Human Geography, Social, Networks, Open Source, Sociocultural, ABI, Behavior, Modeling, Big Data

A16A-T014 TITLE: Technologies to Target Circadian Rhythm Disruption in PTSD

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: To develop and demonstrate a wearable device that can monitor circadian rhythm cycles, determine daytime napping and provide a deterrent to the latter. This device will continuously collect physiological signals, and integrate them in order to estimate circadian rhythm. There may be a companion light modulation component to alter the portion of the light spectrum that regulates the circadian rhythm. The entire package will utilize a smart device which can enable health professionals to carry out further evaluations and repair the disrupted cycle.

DESCRIPTION: Terrestrial species have adapted to the Earth's 24-hour pattern of daylight and darkness by evolving biological rhythms, called circadian rhythms, which repeat at approximately 24-hour intervals. For humans, circadian rhythms are regulated and generated by a master clock located in the suprachiasmatic nuclei (SCN) in the hypothalamus in the brain. Lack of synchrony between the master clock in SCN and the external environment, referred to as circadian misalignment, can lead to circadian disruption, with potential detrimental consequences ranging from increased sleepiness and decreased attention span during the day, lower productivity, gastrointestinal disorders, to long-term health problems such as increased risk for cancer, diabetes, obesity, and cardiovascular disorders. Some of these problems are closely associated with Post traumatic stress disorder (PTSD). At issue for PTSD in Service members is an increase in daytime napping, with the resultant inability to obtain a deep REM sleep (a restful necessity) at night. The insomnia and resultant exhaustion, likely contribute to many of the key issues seen in PTSD (metabolic syndrome, anger, etc.). Circadian rhythm reset is not likely to solve all aspects of PTSD, but could restore this key pathway which has far-reaching involvement with the HPA axis, metabolism, etc. A safe method to solicited to diminish napping, and provide other therapies (such as light adjustments, etc.) as well as to enable health professionals to determine more specific aspects of the circadian disruption. The ideal system will undoubtedly have multiple components, but be relatively user-friendly. Clinical trials using PTSD cases may be possible to test the successful device when it has been optimized. COTS devices currently exist for wearable devices that monitor activity, galvanic skin responses, temperature and other physiologic conditions which are useful especially for PTSD cases. Those devices would supply collected data to a smart device to integrate information and define circadian status. Other COTS devices such as Philips light panel that provides blue light to affect circadian rhythm, offer alternatives for effective regulation of circadian rhythm and avoidance of circadian misalignment. Detection of daytime napping and a strategy to interfere in that process is not currently available. The integration of the various aspects cited would have potential to be an aid in reversal of one of the debilitating aspects of PTSD. The goal of this STTR topic is to leverage the large body of research literature on circadian rhythm and couple it to the advance in wearable/embedded device technologies to develop an integrated circadian rhythm regulation device.

PHASE I: Given the short duration of Phase I, this phase should not encompass any human use testing that would require formal IRB approval. Phase I should focus on system design for rapid realignment of circadian rhythm to the external environment and to develop a strategy for detection and disruption of daytime napping. At the end of this phase, a working prototype of the device(s) and the application(s) should be completed and some demonstration of feasibility, integration, and/or operation of the prototype. In addition, descriptions of data syncing concept, interoperability concerns, and data storage and tracking should be outlined. Phase I should also include the detailed development of Phase II testing plan.

PHASE II: During this phase, the integrated system should undergo human subject testing for evaluation of the operation and effectiveness of utilizing an integrated system and its capability to aid the PTSD cases to avoid daytime napping and achieve real-world outcomes of circadian rhythm regulation, sleep, and alertness. Accuracy, reliability, and usability should be assessed. This testing should be controlled, rigorous. Statistical power should be adequate to document initial efficacy, feasibility and safety of the device. This phase should also demonstrate evidence of commercial viability of the tool. Accompanying the application should be standard protocols and procedures for its use and integration into ongoing programs. These protocols should be presented in multimedia format.

PHASE III DUAL USE APPLICATIONS: The ultimate goal of this topic is to develop and demonstrate a wearable device that can be utilized as a personal circadian rhythm regulation device by synthesizing physiological signals into a circadian rhythm estimate and adjusting circadian light input based on the estimate. This device should also seamlessly integrate with other peripheral device(s), web-based and Smartphone applications, and provide additional feedback and monitoring tools for long term health assessment. The final system will be integrated into other Army informational systems such as ArmyFit and AHLTA. In addition the system may be marketed to commercial consumers for improving general health of shift workers.

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KEYWORDS: Health, Circadian Rhythm, Wearable Device, Technology, Military Health, Activity, Sleep, Alertness

A16A-T015 TITLE: Manufacturing of Flame Resistant (FR) Combat Printed Nonwoven Material

TECHNOLOGY AREA(S): Materials/Processes

OBJECTIVE: To manufacture large scale production run of Flame Resistant (FR) combat printed nonwoven base uniform material for wear test trial on one specific combat item such as the main body fabric of the combat shirt. (Basic material A of GL-PD-10- 02E; Shirt Combat, Flame Resistant dated 19 March 2015).

DESCRIPTION: Except for limited knitted material constructions, all of the military clothing is constructed of woven type materials since the inception of the US military. Nonwoven type constructions for clothing applications are relatively new. Recent developments demonstrate that they are a viable alternative to woven constructions for some military applications with a potential material cost savings of up to 25 percent. Generally, woven based materials require as much as 15 processing steps during manufacturing as compared to only 5 steps for nonwoven manufacturing. Additionally, there are numerous nonwoven manufacturing processing options such as needle-punching, hydroentanglement (HE), melt-blown processing, ultrasonic bonding, Spun-bonding or combination of each to provide unique functional characteristics to the material. Nonwoven materials possess inherent mosquito (vector) protection due to the torturous path characteristic of how the fibers are arranged in the material.

PHASE I: During this research and development phase the contractor shall demonstrate scientific approach feasibility by providing the following:

- A minimum of three viable solutions for a 5.2-5.9 ounces per square yard shirt weight FR nonwoven material, minimum bursting strength of 25 lbs., minimum air permeability of 240 CFM, dimensional stability of 1.0/-7.0 % after 5 washing cycles, maximum after flame of 2 sections, maximum afterglow of 15 seconds, and maximum char length of 5 inches after 25, 50 and 100 laundering cycles.
- The best performing materials would be down selected for preparation into a Phase II full manufacturing run.

PHASE II: Based on the results from Phase I, the best material candidates would be selected for large manufacturing and prototype demonstration capability as follows:
a. Provide a minimum of 750 linear yards, 60 inch wide, flame resistant (FR) nonwoven material, OCP camouflage printed, water-repellent treated and enhanced hand and drapeability comparable to Basic material A of GL-PD-10-02E; Shirt Combat, Flame Resistant dated 19 March 2015.
b. Full verification lab testing for physical properties and FR will need to be performed (vertical flame and thermal manikin tests) as applicable on each material type.
c. Upon verification of both physical and FR properties. A minimum of 100 Army combat shirts in the standard sizing tariff shall be provided as a deliverable to the PM for user evaluations.

PHASE III DUAL USE APPLICATIONS: Nonwovens offer a vast opportunity for both military and commercial applications in numerous lines of outdoor clothing. For military applications: combat uniforms of all types, i.e., combat vehicle crewman (CVC), uniforms for pilots, ground troops, and other protective items such as coveralls (Navy is currently testing a protective coverall for shipboard welding). For commercial applications: hunting uniforms, utility work clothing, disposable clothing and super low cost FR and non-FR children's wear. This product would also be ideal for children/adults living in Africa and Philippines who face the threat of disease borne mosquitoes because the nonwoven fabrics provide some vector protection due to their fiber construction properties.

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KEYWORDS: Nonwovens, Water-Repellent (WR), Hydroentangled (HE), Spunbonded, Flame Resistance (FR), Combat uniforms

A16A-T016 TITLE: Spectrum Analyzer Using Spintronic Radar Arrays

TECHNOLOGY AREA(S): Sensors

OBJECTIVE: Research and development of new ultra-fast spintronic radar detectors and spectrum analyzers based on arrays of metallic or metal/insulator nano-scale magnetic diodes. These novel devices have the potential to become practical microwave detectors for military applications. They can be scaled down to ultimate nanometer sizes, they have a very low power consumption, natural frequency selectivity, ability to process very noisy external signals and are not vulnerable to ionizing radiation.

DESCRIPTION: The proposed spintronic radar detectors and spectrum analyzers will be essential in future anti-radar and wireless interception and active interference (jamming) systems of ground combat vehicles. The objective of this project is to develop the theory of operation and the design of a novel ultra-fast spectrum analyzer and frequency detector based on randomized arrays of nano-sized spin-torque microwave diodes. The device can be used for anti-radar activities, counter-terrorist operations, military intelligence and other battlefield applications. As the result of this research and development effort, prototype nano-sized spintronic spectrum analyzers will be developed, tested and delivered to TARDEC. The operation of the proposed spintronic spectrum analyzer is based on the recently discovered spin-torque diode effect in magnetic multilayered nanostructures [1-4]. The spin-torque microwave diode (STMD) is nano-sized, naturally frequency-selective, radiation hard and could work in a passive regime with no power consumption. Required specifications are the following: capable of determining the carrier frequency of the incoming radar signals in less than 200 ns; an operational bandwidth of several GHz; frequency resolution better than 50 MHz; and tuneability from 3 to 20 GHz .

PHASE I: Develop theory of regular and randomized linear arrays of spintronic radar detectors and theory of correlation-based spectrum analysis of incoming microwave signals in such arrays. The first milestone will be the theoretical demonstration that the spectral analysis of the incoming signals in coupled arrays of STMD could be performed in less than 500 ns.

PHASE II: Use mathematical modeling and simulation to optimize the spectrum analyzers' working characteristics, such as power sensitivity, frequency resolution and time interval of frequency analysis. The final milestone will be the optimized design of the device and delivery of a prototype spintronic radar array of 6 or more detectors, fabricated on a single chip, covering the frequency interval of 2 – 10 GHz.

PHASE III DUAL USE APPLICATIONS: Continue to improve the nanofabrication process, using the electron-beam lithography, to achieve 20 - 40 spintronic radar detectors on a single chip. Evaluate reliability across the microwave spectrum to assess power output levels sufficient for energy harvesting and various applications of interest to military and civilian markets. Spintronic devices are not sensitive to ionizing radiation and could be used in space and on a battlefield. Evaluate possible civilian applications in automotive industry, including ultra-fast side-impact radars and control of autonomous vehicles.

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KEYWORDS: spintronics, radar detectors, metamaterials